# PUPIL POSITION MEASURING APPARATUS AND METHOD

## FIELD OF THE INVENTION

The present invention relates to ophthalmic equipment for eye-testing and spectacle setting. More specifically the invention is concerned with an apparatus and a method for accurately determining the position of the pupils of an individual and for correctly positioning lenses with respect to a spectacle frame of the individual.

## BACKGROUND OF THE INVENTION

When an individual requires corrective eyeglasses, it is extremely important that the corrective lenses be positioned in proper relationship to the individual's line of vision (in alignment with the individual's pupils and a viewed object). In particular this is the case when considering bifocal or multifocal lenses (also referred to as progressive lenses). However, this information is useful also for diagnostic and research purposes.

In order to obtain correct measurements, it is important that such measurements be carried out while the individual is wearing the eyeglasses at a normal and comfortable position (corresponding with how the wearer will use the eyeglasses), such that the relative positioning of the lenses with respect to the individual's eyes is most accurate. This measurement problem is further compounded by the fact that present day eyeglass frames take a wide variety of shapes and sizes ranging from generally circular in shape to various oval configurations. Additionally, any such measuring apparatus should also be capable of accommodating the so-called frameless eyeglasses as well as wire rim frames, etc. Even more so, it is important that the lenses be fitted in the frame in correspondence with the

individual's regular activities, i.e. driving, reading, computer use, TV watching, outdoor activities, etc. and that measurements be taken at different positions i.e. leaning over, walking, sitting, etc.

A variety of measuring techniques and devices were proposed throughout the years, some of which are simple but not reliable and non accurate, e.g. when using manual measuring techniques. Other techniques are complicated to use thus requiring substantial amounts of time in obtaining the desired measurement. Others of these techniques and devices do not tend to be sufficiently accurate or may result in movement of the eyeglass frames during a critical portion of the measuring process. Still other devices may be well suited for use with a particularly shaped eyeglass frame but may be unsuitable with respect to other shapes or types of frames such as the so-called *frameless/rimless* eyeglasses, *wire-rim* frames, etc.

U.S Patent Nr. 4,653,192 to Conard et al. discloses an apparatus for use in accurately determining the vertical position for the line of demarcation between the bifocal correction lens and other corrective lens segments to be provided in eyeglass lenses. The measuring apparatus includes an elongated indicia carrying member having provided thereon adjustable clamping members specifically designed to enable the elongated member to be attached to a wide variety of eyeglass frames for purposes of obtaining a measurement of the proper height for location of the segment line. The elongated member also includes a sliding gauge which may be moved there-along and cooperates with the indicia to provide an accurate, easily determined measurement for the position of the segment line.

U.S. Patent Nr. 4,494,837 discloses a pupil location gauge having an index member movable in relation to a graduated scale for use in an ophthalmic test lens holder for subjective measurement of both vertical and horizontal pupillary distance. Either monocular or binocular measurements of the pupil location may be made with respect to a spectacle frame.

It is an object of the present invention to provide an apparatus and a method for carrying out ophthalmic measurements so as to obtain correct measurements indicating the position of an individual's pupils and to indicate correct positioning of

lenses in proper relationship to the individual's line of vision with respect to a particular eyeglass of the individual.

## SUMMARY OF THE INVENTION

According to the present invention there is provided a method for measuring an individual's pupil position (PP) in relation to a particular eyeglasses frame, wherein a display module (DM) is attached to the eyeglass's frame and a graphic image displayed on the DM is displaced until it extends in alignment with the individual's pupils, whereby the coordinates of the alignment location are registered to obtain the PP.

The above method comprises many embodiments, for example:

- The display module may be attached to the eyeglass's frame at a recognizable relation, or the relative position of the DM with respect to the eyeglass's frame may be determined through or after the process;
- The graphic image may be displayed so as to interfere with the individual's line of vision while staring at a target mark;
- The method may be carried out for determining the PP for both eyes simultaneously or separately for one eye at a time;
- The graphic image may be part of a virtual image perceived upon blending of the graphic image with the target mark;
- The graphic image may be part of a virtual image perceived upon blending of a graphic images simultaneously displayed in front of each eye.

The present invention is also concerned with a system for measuring an individual's pupil position (PP) in relation to a particular eyeglasses frame, the system comprising a fixture member for attaching to the eyeglasses frame at a recognizable relation, at least one display module (DM) suited for displaying a graphic image on the DM, a control unit for controlling and displacing the graphic

image, and a register for picking up the coordinates of the graphic image location at selected positions.

Once the coordinates of the PP are registered they may be used for different purposes and in various ways. When the information is needed for shaping lenses so as to fit within the particular eyeglass of the individual, e.g. when fitting bi-focal or multi-focal lenses, the information may be directly applied to raw lenses fitted on the frame. Alternatively, the coordinates of the frame are obtained and the coordinates of the PP are superimposed (during or after the process) so the raw lenses may then be machined according to this information.

## BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, some embodiments will now be described, by way of non-limiting examples only, with reference to the accompanying drawings, in which:

**Figs. 1** schematically illustrates a system in accordance with the present invention, wherein:

**Fig. 1A** is a front view of an individual wearing eyeglass and fitted with a system according to the invention;

**Fig. 1B** is a side view of Fig. 1A;

**Fig. 2A** illustrates a system according to an embodiment of the present invention;

**Fig. 2B** is a local section of the portion marked I in Fig. 2;

**Fig. 2C** is an isometric representation of the portion marked II in Fig. 2;

**Figs. 3A** to **3C** illustrate several options of a display module according to the present invention;

**Fig. 4A** illustrates a system according to another embodiment of the present invention, at a first position;

**Fig. 4B** illustrates the embodiment of Fig. 4A at a second position.

## DETAILED DESCRIPTION OF THE INVENTION

Attention is first directed to Figs. 1A and 1B of the drawings illustrating a system in accordance with the present invention generally designated **10** mounted on a pair of spectacles (eyeglass) **12** of individual **14**.

The system **12** comprises a fixture member generally designated **20** which will be discussed in further detail with reference to Figs. 2. The fixture member of the embodiment seen in Figs. 1A and 1B supports a pair of display modules (DM) **24** which at use extends opposite the individual's eyes.

The system further comprises a control assembly **28** (Fig 1A) which in the present embodiment comprises a processor **30** and a controller **32** which in the present embodiment is a hand-held remote control device transmitting and receiving data to and from the device **20** and the controller **32**. It is however appreciated that communications may be by a variety of different means, i.e. wire communication, IR communication, RF communication, etc. and further, that the controller **32** may be fitted with digital controls or mechanical controls.

In general, the fixture member **20** is of lightweight and does not interfere with wearing the eyeglass **12** whereby the individual **14** is comfortable during the measurement process.

With further reference being made to Figs. 2A-2C, fixture member **20** has a frame-like structure fitted at a top center portion thereof with a nose-bridge engaging mechanism **36** fitted for self-centering about the bridge **38** of the eyeglass frame **12**. The mechanism **36** comprises a pair of arms **40** pivotally mounted at **42** to an extension **44** of the frame-like portion **46**. The arms **40** are spring biased so as to clampingly engage over the nose bridge **38** of the eyeglass and to self-center thereabout. Arms **40** bias the spectacle frame **12** downwards whereby a lower portion of the spectacle frame **50** (or of a raw spectacle lens in case of rimless eyeglass) engages into a receptacle portion **52** of the frame **46** of the device **20** and is securely nested by means of a leaf spring **58** so as to eliminate or reduce slack between the spectacle frame **12** and the frame **46** of device **20**.

Display modules **24** are fixed to the frame **46**, symmetrically positioned. The display modules (DM) may be a variety of display screens, e.g. an LCD screen or any other suitable graphic display module capable of displaying various patterns and images as well as changing its transparency through the range of transparent to opaque, as will be explained hereinafter in more detail with reference to Figs. 3A-3C.

According to some particular embodiments, the graphic image may be part of a pattern or scheme which when blended with another graphic image (i.e. displayed for another second eye) is perceived as a virtual image. For example, the graphic image may be a first colored pattern (for example a blue circle) displayed in front of one eye and a second colored pattern (for example a yellow circle) displayed in front of the other eye, where only when both graphic images are in alignment with the respective pupils, a third color is perceived (a green circle in the particular example). The same result may be achieved by using other figures, e.g. geometric shapes. For example, if inverted half circles are displayed in front of each eye, the resultant perceived image, when both half circles are in alignment with the respective pupils, when both graphic images are in alignment with the respective pupils will be a complete circle.

A person versed in the art will appreciate that the image may be a reality image or a virtual image.

Similarly, if the target image constitutes part of the virtual image and the displayed graphic image (displayed on the DM) constitutes the other part of said virtual image, the resultant virtual image upon intersection of the graphic image with the line of vision, while staring at the target image, will be perceives as said virtual combined image. Accordingly, each eye may be presented with different images.

As already mentioned hereinabove, the process of locating and measuring the PP may be carried out by locating the point of intersection of the graphic image with the individual's line of vision while staring at a target mark (typically distant, from the individual) and also by displaying an image on a display monitor giving rise to a

virtual image mimicking a distant image, and then locating the position of the individual's pupils when they are aligned and staring at the virtual image.

As an example, a display module (DM) according to an embodiment of the invention, is of the type known as a *personal monitor* (PM), where a high resolution color image is created in the individual's eyesight. The personal monitor is a monoscopic biocular display with a relatively narrow field of view, which can receive video signals from any video source. The signals are converted in the controller unit into signals driving the electronics of the LCD displays. The PM takes standard signals and displays them on a small TFT LCD display module that can be connected to any standard signal source e.g. video, computer, etc. The device comprises lenses and mirrors that project the displayed image into the retina of the eyes. The PM has a mounting slot that fits onto the nose piece of the eyeglasses.

However, other display modules are suitable for use with the present invention, e.g. so called reflective displays, etc.

The display module is typically a thin and lightweight surface which, in accordance with some particular embodiments, may have changing optical parameters to comply with near sighted or far sighted individuals (myopia/hyperopia) and further to adjust the brightness of the graphic image displayed on the module, depending on lightening conditions, etc. furthermore, it may be possible to adjust different optical parameters according to correcting tables, etc. in addition, some other optical elements may be used in conjunction with the apparatus of the invention. For example, power correcting lenses may be applied to correct sight deficiencies of the patient, filtering elements (e.g. to overcome glare, etc), prisms, etc.

The graphic image displayed on the display modules **24** is displaceable about the display module and is controllable by means of a controlling assembly (e.g. in Fig. 1A comprising processor **30** ad controller **32**) which in the present embodiment is by wireless means and for that purpose a receiver/transmitter unit **64** is mounted on the frame **46**.

In practical use, the device **20** in accordance with the present embodiment is securely fixed over the spectacle frame **12** and the eyeglass are then comfortably worn by the individual, as if the device **20** is absent. At this position, the coordinates of the spectacle frame **12** with respect to the frame **46** of device **20** are measured and registered by processor **30**. Then, the individual is requested to stare at a target mark (**68** in Fig. 1B; such a target mark may be a sign marked on a board or wall at a predetermined distance, etc.) and a graphic image is then displayed on the display module **24**. The individual is requested to displace the graphic image (**70A** in Fig. 2A) until the graphic image interferes with the individual's line of vision **74** (Fig. 1B) while staring at the target mark **68**.

The process may repeat several times (using the same graphic images or different ones at each time and optionally changing the size and distance of the target mark) and each time the graphic image intercepts with the individual's line of vision a point of interception is registered into the processor **30**, e.g. by use of the control unit **32**.

It is appreciated that the test may be carried out by the individual or by the professional. It is further appreciated that the measurements may be carried for one eye at a time while the other eye may be comfortably kept open and the display module in front of that eye may be darkened or made opaque to prevent sight interference. Alternatively, the measurement may be carried out for both eyes simultaneously.

At the end of the measurement process, processor **30** generates the coordinates of the pupils **76** with respect to the true position of the eyeglass frame **12**, based on the processed data registered by the processor **30**. The information may be processed by different statistic analysis as known *per se* with or without using correction factors to compensate and adjust for different parameters.

The arrangement may be such that during a measuring process the graphic image is constantly displayed and displaced, or, the graphic image may be displayed each time at a different position in a non-continues fashion.

The data concerning the position of the pupils **76** may be used in different ways and for different purposes such as, for example, for machining spectacle lenses according to optic prescriptions, research and study, etc.

It is appreciated that measurements of the pupils' position may be carried out for far distance and for near distance (i.e. reading position) which is advantageous in particular for manufacturing of multi focal lenses whereby indications are provided for determining the position of the individual's eyes during such positions.

With further reference now to Figs 3A-3C, there are illustrated several examples of display modules in accordance with the present invention. In Fig. 3A there is illustrated a display module **80** where the graphic image is in the form of a target mark **82**. However, this target mark may have various shapes, e.g. circular, triangular, rectangular, etc., as exemplified in Fig. 3A and marked **84-88**, respectively. In this example the display module **80** is substantially translucent and the graphic image is a fine image displayed on the screen to facilitate *"aiming"* by displacing the graphic image to intercept with the line of sight.

In the embodiment of Fig. 3B, the display module **92** is opaque whilst the graphic image **94** is a translucent image, in the present example being a circle. In this embodiment, the translucent portion **94** is displaced until the image appears through the translucent portion. In order to facilitate location of the target mark through the miniature graphic image **94**, the background of the display module may gradually change from translucent to opaque. Alternatively, the translucent graphic image **94** may have a *"keyhole"* like shape where a larger landscape portion may be visioned though the opaque background to facilitate focusing of the target mark to the graphic image.

In the embodiment of Fig. 3C, the display module **98** is translucent whilst the graphic image **100** is a dark spot, circular in the present embodiment.

With further reference being made to Figs. 4A and 4B, there is illustrated a modification of a device in accordance with the present invention generally designated **106** which is principally similar to the device **20** in Fig. 2A with the exception that the device **106** is a single module device comprising a self-centering

clamping mechanism **108** similar to the arrangement of Fig. 2A and a similar engagement portion **110** at a lower part of the frame **112** whereas the frame **112** is either pivotal about an access **116** extending from mechanism **108** or mounted each time in front or behind a different lens **120A** and **120B** of the spectacle frame **124**. similarly, the DM may be mounted within the specific eyeglass frame.

It is appreciated that a variety of attaching mechanisms are available for securely attaching the frame of the device in accordance with the present invention to a variety of different eyeglass frames. Such a device may be attached to both raw lenses or to one lens at a time. It is further to be clear that the DM may by itself attachable to the eyeglass without the need for additional support frame. For example, the device may be attached to the spectacle frame by vacuum-suction cups attached to raw lenses of the eyeglass. Other attachment means may be, for example, magnet arrangements, clips or snap-on arrangements, etc.

Whilst some embodiments have been described and illustrated with reference to some drawings, the artisan will appreciate that many variations are possible which do not depart from the general scope of the invention, *mutatis, mutandis*.